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ABSTRACT

A study was conducted to determine the effect of graphic format--bar, line, table, and line-table graph--on the interpretation of numerical data by field dependent and field independent students. Ninety-six undergraduate students were given the Group Embedded Figures Test and randomly assigned to one of four treatments. During the testing phase, the subjects were given a fictitious narrative concerning income amounts of various European merchants during the Middle Ages and shown the quantitative data in one of the graphic formats on a 35mm slide; the order of the questions was randomly altered for each treatment. All subjects in all treatments responded to the same questions, each of which required a numerical or verbal answer as either a specific amount or a static or dynamic comparison of the data. A two-way analysis of variance was used to test the research hypothesis. Results indicated that scores were lower for the line graph treatment than for the table treatment for all three types of questions. Subjects viewing the bar graph did not differ from the line graph treatment for any types of questions, but had lower scores for the amount and static questions compared to the scores of the table treatment. It is suggested that the poor performances of the line treatment group and the bar group on the static questions give rise to the need for additional experimental work. This study partially confirms an earlier study which found that tabular reports are better than graphical formats, but does not produce much evidence that there is a strong relationship between field dependence/independence and the scores on the different types of questions. (8 references) (CGD)

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The Effect of Graphic Format and Cognitive Style on the Recall of Quantitative Data

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The Effect of Graphic Format and Cognitive Style on the Recall of Quantitative Data

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The Effect of Graphic Format on the Interpretation of Quantitative Data

Introduction

The power provided by computer graphics systems has greatly facilitated the production of professional quality graphic materials. The versatility provided by the software has made it possible to present numerical information in a multitude of chart formats. Most software packages allow the users to readily display the same data in a variety of different formats by a few simple keystrokes. However, educators and instructional designers still lack the empirical evidence to assist them in determining the "right" type of graphics to use in a given learning situation.

Washburne (1927) investigated the effects of tabular, textual, and graphic arrangements on recall. This study tested recall of specific amounts, as well as static and dynamic comparisons and rank ordering. Watson and Driver (1983) found that three dimensional graphic plots did not result in greater recall of information than did tabular presentation data. Benbasat and Dexter (1986) concluded that tabular reports led to better decision making and graphical reports led to faster decision making when time constraints were low. However, a combined graphical-tabular report was found superior in terms of performance. Even though the use of graphics in instruction has generally been recommended in the literature (e.g., Miller, 1969; Shostack & Eddy, 1971; Takeuchi & Schmidt, 1980), there have not been extensive studies which investigated the effects of these formats on recall.

The general advantages of graphics in presentations have been delineated by Watson and Driver (1983). Some of these advantages include 1) the ability to stimulate the interest of the user, 2) to aid in grasping relationships, 3) to save time when viewing masses of data, 4) present at a glance a comprehensive view of the relationship between different categories of information, and 5) to assist in analytical thinking. However, there appears to be a lack of research that supports the above claims. Winn (1987, p. 192) stresses the importance of developing "lines of inquiry into the learning strategies studies use when working with graphic forms." It is important to discover how and what students are learning from graphics. Are some graphics more effective than others? Are some types of information better presented different in graphic forms? Designers and producers of visual materials must also be concerned with a number of considerations included the nature of the instructional task, the teaching and learning strategies to be employed, and the individual characteristics of the learner.

The term cognitive style has been employed to describe strategies or models of perceiving, organizing and processing stimuli. The cognitive style of field dependence has been singled out as having major implications in the use of visual materials. Field dependence is important because it involves perceptual and problem-solving abilities, structuring a stimulus field, breaking up or disembedding such a field, suppressing irrelevant information, and dealing with high information load, all of which are relevant in the interpretation of data in graphic format. More specifically, it is of interest if there is any correlation between the various graphic

formats and those individuals who are classified as field-dependent or field-independent. Field dependent students may have difficulty processing complex visual information (i.e., as a graphic format) unless it is presented in such a way as to compensate for specific processing deficiencies related to field-dependence.

Research Questions

The purpose of this study was to determine the effect of graphic format on the interpretation of numerical data. The formats used in this study were bar, line, table, and line-table graph. The three types of quantitative interpretation that were tested were specific amourts, and static and dynamic comparisons. It was also of interest to determine whether cognitive style (FD/FI) correlated with the ability of the subjects to interpret information in any particular chart format.

Methodology

The subjects for this study were 96 undergraduate college students enrolled in professional education classes or introductory educational psychology classes within the College of Education. The subjects were given Group Embedded Figures Test (Witkin, Oltman, Raskin & Karp, 1971). The scores range from 0-18 with the higher scores indicating tendency toward field dependence.

The subjects were randomly assigned to one of four treatments which presented fictitious data in graphic form to alleviate any effect of prior knowledge. The fictitious data dealt with various European merchants income during the middle ages. The four treatments presented the same data in the following formats: 1) bar graph, 2) line graph, 3) table and 4) line-table combination. During the testing phase subjects responded by giving numerical or verbal answers in three categories: specific amounts as well as static and dynamic comparisons of the data. Example questions for each category are presented below.

Specific Amount

What was the income of the silk merchants in the year 1100?

Static comparison

Which group of merchants had the highest income in the year 1350?

Dynamic comparison

Which group of merchants had the greatest increase in income between the years 1100 and 1200?

All subjects in all treatments answered the same questions (each in the above three categories) the order of which was randomly altered for each treatment. The subjects were given the fictitious narrative and then shown a graphic format of the

quantitative data, e.g., line graph on 35mm slide. The subjects had seven seconds to respond to each question while looking at the treatment slide, e.g., line graph.

A two-way analysis of variance was used to test the various null hypothesis in which the independent variables are type of graphic and type of recall. The design was 3 x 2 factorial design based upon a mixed model which used a combination of between and within subjects methods (all subjects would respond to all types of questions) while viewing only one type of graph. The dependent variable was the interpretation of quantitative information. A correlation was conducted using the raw scores total and score on the (GEFT) (0-18) for each subject.

Results

The means of the raw scores are presented in Table 1 and the means of the scores as percent correct responses are presented in Table 2. A two dimensional (3x2) analysis of variance design was employed to test the research hypothesis. The summary table of the analysis of variance based upon the table of means (Table 1) is presented in Table 3. A total of 96 subjects were used in this analysis. The F ratio for type of graph ($F(3,92) = 4.71$, $p < .005$) was significant. The F ratio for type of question ($F(2,184) = 46.56$, $p < .0001$) was also significant. The $F(6,184) = .107$, $p > .05$) between type of graph and type of question was not significant. The correlation coefficient of scores on the GEFT and the scores on the three types of questions was as follows: amount = 0.078, static = 0.182, and dynamic = 0.381. Figure 1 is a graphical representation of the means of the percent scores as function of type of graph and type of question.

Discussion

The post-hoc analyses of comparisons of means showed that Ss viewing the line graph had lower scores than for the table treatment for all three types (amount, static, dynamic) questions. This is a predicted result for the amount questions because the subjects simply had to read the data from the table. However, since the static and dynamic questions required the Ss to do comparisons in a given year (static) and scan across years (dynamic), the poor performance of the line treatment was unexpected and merits additional experimental work.

Subjects viewing the bar graph did not differ from the line graph treatment for any types of questions, but had lower scores for the amount and static questions when compared to the table treatment. The bar graph scores did not differ from the table for dynamic questions. The relatively poor performance of the bar group on the static questions also merits additional work. Future studies of this type should increase the amount of data in the table and decrease the time of each trial. Both of these conditions would provide a better approximation to conditions in a classroom or business meeting.

This study partially confirmed the results of Benbasat and Dexter (1966) in that tabular reports were better than graphical formats, but did not find that combined

Table 1. Mean Raw Score as a Function of Type of Graph and Type of Question

Graph Type	Type of Question			Mean
	Amount	Static	Dynamic	
Line	12.67	12.83	10.63	12.04
Bar	12.83	12.96	11.58	12.46
Table	13.63	13.67	12.29	13.19
Line-Table	13.54	13.00	12.29	12.94
Mean	13.17	13.12	11.70	12.66

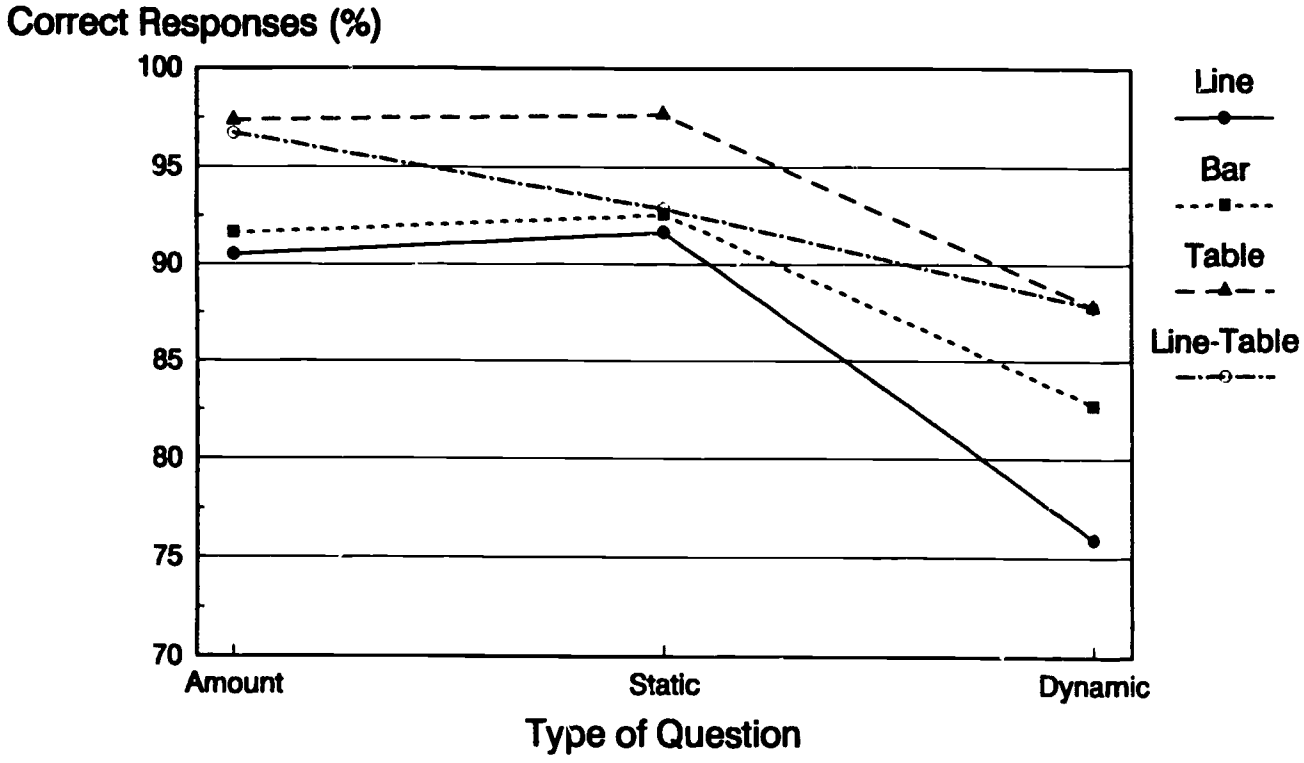
Table 2. Mean Percent Score as a Function of Type of Graph and Type of Question

Graph Type	Type of Question			Mean
	Amount	Static	Dynamic	
Line	90.50	91.64	75.93	86.00
Bar	91.64	92.57	82.71	89.00
Table	97.36	97.64	87.78	94.21
Line-Table	96.71	92.86	87.78	92.43
Mean	94.07	93.71	83.57	90.43

Table 3. Summary of Analysis of Variance

Source	df	SS	MS	F	p
Between subjects					
G (Type of Graph)	3	56.85	18.95	4.71	< 0.005
Subjects w. groups	92	369.81	4.02		
Within subjects					
Q (Type of Question)	2	133.34	66.67	46.56	< 0.001
G X Q	6	15.22	2.54	1.78	n.s.
Q X subjects w. groups	184	263.44	1.43		

Figure 1. Percentage Correct Responses as a Function of Chart Type and Type of Question



tabular and graphical (line-table) were superior to table in terms of performance. However, the Ss in Benbasat and Dexter (1966) did have much larger data sets to interpret which would favor the combined format.

This study did not produce much indication that there is a strong relationship between field dependent/independence and the scores on the different types of questions. However, it does not preclude the future investigation of cognitive style and the type of graphic presentation.

The preliminary nature of this study does not lend itself to conclusions which can be readily translated into specific recommendations for selecting graphic formats for business or educational environments. However, it does provide a basis for additional work which might lead to such practical applications.

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